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ATTENTION: APPLICATION BRANCH

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): MING-TSUN HSIEH

For: METHOD OF DEFFECTIVE PIXEL ADDRESS DETECTION FOR IMAGE SENSORS

Enclosed are:

- (X) Specification in (12) pages.
- (X) (2) sheets of drawings.
- (X) Recordation Form Cover sheet with (2) page assignment.
- (X) **SIGNED** declaration and power of attorney.
- () Verified statement (Declaration) claiming small entity status.
- () A certified copy of () Patent Application No. ____ dated ____.
- (X) Return prepaid postcard.

CLAIMS AS FILED

| FOR | NUMBER FILED | NUMBER EXTRA | RATE | FEE |
|--|-------------------------|-----------------|-------|-------|
| Basic Fee | | | \$690 | \$690 |
| Total Claims | 13 - 20 = 0 | × | \$18 | \$0 |
| Independent Claims | 3 - 3 = 0 | × | \$78 | \$0 |
| If application contains any multiple dependent claims(s), then add | | | \$260 | \$0 |
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| For a small entity: | TOTAL FILING FEE | | | \$ |

- (X) A check in the amount of \$ 690 to cover the filing fee is enclosed.
- (X) A check in the amount of \$ 40 to cover the assignment recording fee.
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METHOD OF DEFECTIVE PIXEL ADDRESS DETECTION FOR IMAGE SENSORS

CROSS-REFERENCE TO RELATED APPLICATION

5 This application claims the priority benefit of U.S. Provisional Application serial no. 60/217,824, filed July 12, 2000, the full disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

10 Field of Invention

 The present invention relates to a method of pixel address detection of an image sensor. More particularly, the present invention relates to a method of defective pixel address detection of an image sensor.

Description of Related Art

15 As the multimedia era is coming, digital information, such as digital images or digital movies, becomes more popular. Modern technology has highly developed, and the cost of image sensors for generating digital images or pictures reduces. More people can access these high technological products. However, there are still some problems about the image sensors.

20 Due to the current process, it is hard to fabricate an image sensor perfectly without any bad or defective pixel thereon. Therefore, there are always some defective pixels on the image sensor after it is fabricated. The image or picture sensed by the defective pixels will affect the quality of the image or picture. And the following imaging procedure, such

as color processing or image compressing etc, will also affected. How to reduce the effect of the defective pixels of the image sensor becomes a significant topic.

SUMMARY OF THE INVENTION

The invention provides a method of defective pixel address detection for an image
5 sensor. The method comprises: (a) comparing a defective pixel address with a sensor
address, wherein the defective pixel address is stored in a memory element in advance
when the image sensor is tested; (b) outputting a defective pixel flag if the sensor address is
equal to the defective pixel address; (c) increasing an index value by one unit and returning
to the step (a); (d) comparing the defective pixel address with an empty signature if the
10 sensor address is not equal to the defective pixel address; (e) increasing the index value by
one unit if the defective pixel address is equal to the empty signature, and returning to the
step (a); and (f) returning to the step (a) if the defective pixel address is not equal to the
empty signature.

The invention provides a method of defective pixel address detection for an image
15 sensor. The method comprises the steps of: storing a plurality of defective pixel addresses
during the image sensor is tested. A pixel address of the image sensor is read and then
one of the defective pixel addresses is fetched. The first fetched defective pixel address is
compared with the pixel address of the sensor address. If the pixel address is equal to the
defective pixel address a defective pixel flag for indicating the current pixel is bad is
20 outputted, and then an index value is increased by one unit. Another defective pixel
address which is indexed next to the first fetched defective pixel address is further fetched.
The defective pixel address is further compared with an empty signature if the pixel address
is not equal to the defective pixel address. The index value is then increased by one unit if

the defective pixel address is the empty signature, and another defective pixel address which is indexed next to the first fetched defective pixel address. Another defective pixel address which is indexed next to the first fetched defective pixel address is further fetched if the defective pixel address is not the empty signature.

5 Advantageously, the present invention provides an effective and efficient method for determining whether the pixel of the image sensor is defective, by which the following color processing and image compression etc can be significantly simplified. In addition, the method of defective pixel address detection for image sensor is in a simple and low cost way.

10 It is to be understood that both the foregoing general description and the following detailed description are exemplary, and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

15 The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. In the drawings,

20 Fig. 1 schematically shows a block diagram for carrying out the method of the present invention according to one preferred embodiment of this invention;

 Fig. 2 illustrates a schematic diagram of the format of the storage unit for fully storing the defective pixel addresses according to one preferred embodiment of this invention;

Fig. 3 illustrates a schematic diagram of the format of the storage unit for storing the defective pixel addresses with empty signatures according to one preferred embodiment of this invention; and

Fig. 4 schematically shows a flow chart of the method of defective pixel address detection for image sensor.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 schematically shows a block diagram for carrying out the method of the present invention. The circuit of defective pixel address detection for an image sensor comprises at least a memory element 10 and an address comparator 20. The memory element 10 is used for storing the defective pixel addresses which are detected during the image sensor is tested. The memory element 10 can be a fuse array, for example. The address comparator 20 receives a current sensor address of the image sensor Sensor_addrSensor_addr and fetches a defective pixel address Def_pixel_addr from the memory element 10. The address comparator 20 then compares the two addresses, Sensor_addrSensor_addr and Def_pixel_addr. If the two addresses Sensor_addrSensor_addr and Def_pixel_addr are the same, which means a hit, the address comparator 20 generates a flag bit F to indicate that the current sensor address of the image sensor is a defective pixel. The index of the memory element 10 is increased by one unit, such as 1, to begin another cycle of address comparison. If the two addresses Sensor_addrSensor_addr and Def_pixel_addr are not the same, which means a miss, the address comparator 20 sets the flag bit F to a value, such as 0, to indicate that the current sensor address of the image sensor is a good pixel. And then another cycle of address comparison is begun.

Fig. 2 illustrates a schematic diagram of the format of the storage unit for storing the defective pixel addresses. As shown in Fig.2, for example, the memory element 10 contains 128 addresses, which are indexed from 0 to 127. Each indexed address may consist of a row address and a column address of every defective pixel address, for example.

5 In this embodiment, the defective pixel address of index 0 is 0000_0000_0000_0000_0100. For convenience, the defective pixel addresses stored in the memory element 10 is in an ascending order, but not limited in the present invention. In the example shown in Fig. 2, the memory element 10 is full of the defective pixel addresses. When the index is pointed to the last one, the index 127, of the memory element 10 and there is a hit, the index is

10 wrapped around to the first one, the index 0, of the memory element 10.

Fig. 3 illustrates a schematic diagram of the format of the memory element 10 for storing the defective pixel addresses. As shown in Fig.3, for example, the memory element 10 contains 128 addresses, which are indexed from 0 to 127. Each indexed address consists of a row address and a column address of every defective pixel address, for

15 example. For convenience, the defective pixel addresses stored in the memory element 10 is in an ascending order, but not limited in the present invention. However, in the example shown in Fig. 3, the total number of the defective pixels is less than that of the memory element 10, each of the remained spaces of the memory element 10 is stored with an empty signature for indicating that no more defective pixel address is stored. The

20 empty signature, for example, has a format of 1111_1111_1111_1111_1111. The index 126 and index 127 are examples for empty signature. When the empty signature is read, the index is forced to be increased by one. Similarly, when the index is pointed to the last

one, the index 127, of the memory element 10 and there is a hit, the index is wrapped around to the first one, the index 0, of the memory element 10.

The method of defective pixel address detection for image sensor is described in detail according to Fig. 4. Fig. 4 schematically shows a flow chart of the method of defective pixel address detection for an image sensor.

The feature of the algorithm of the present invention is that the addresses of the defective pixels are put in the memory element (item 10 as shown in Fig. 1) in a specific order, such as an ascending order. Therefore, if there is a hit, the index can be simply increased by one unit, such as 1, and then another address comparison cycle is begun.

Referring to Figs. 4 and 1, according to the embodiment of the present invention, after an image sensor is fabricated, the image sensor is tested for finding defective pixels on the image sensor. The detected defective pixel addresses are then stored into the memory element 10 in an ascending order. The memory element 10 further comprises an index for indicating the current fetched defective pixel address, which as shown in Fig. 2 or Fig. 3.

As the image sensor operates, a reset step is performed, by which the index of the memory element 10 indicates the first location that will be fetched first as following, and the image sensor is set to the first pixel waiting for sensing.

When the sensing process begins, the pixel addresses of the image sensor are read in sequence. After one pixel address of the image sensor is read by the address comparator 20, the address comparator 20 further fetches a defective pixel address indicated by the index 0 from the memory element 10.

As shown in Fig. 4, the step S30 is then performed. The address comparator 20 receives the pixel address of the image sensor Sensor_addr and the defective pixel address

Def_pixel_addr, and compares the two addresses. If the address Sensor_addr hits the address Def_pixel_addr, which means the same, the step S32 is performed. Namely, the address comparator 20 outputs a defective pixel flag F for indicating the current pixel of the image sensor is a defective or bad pixel.

5 After the defective pixel flag F is outputted, the step S34 is performed to increase the index of the memory element 10 by one, for example index 1 as shown in Fig. 2 or 3. After the index is increased by one, another address comparison cycle begins. Namely, the address comparator 20 read another pixel address of the image sensor and next defective pixel address indicated by index 1.

10 In the S30 of the address comparison, If the address Sensor_addr misses the address Def_pixel_addr, which means not the same, the step S36 is performed. Namely, the address comparator 20 sets the defective pixel flag F to a specific value, such as 0, for indicating the current pixel of the image sensor is a good pixel.

15 At the step S36, when address Sensor_addr and address Def_pixel_addr are not the same, whether the address Def_pixel_addr is an empty signature is determined. The empty signature, for example, has a format of 1111_1111_1111_1111_1111. The index 126 and index 127 are examples for empty signature. When the empty signature is detected, the index is forced to be increased by one. Namely, the empty signature of the defective pixel address is detected, the step S34 is performed to increase the index by one.

20 After the index is increased by one, another address comparison cycle begins. Namely, the step S30 is performed and the address comparator 20 read another pixel address of the image sensor and next defective pixel address indicated by index 1.

Furthermore, at the step S36, if the defective pixel address is not an empty signature, the procedure returns to the step S30. The address comparator 20 read another pixel address of the image sensor and next defective pixel address indicated by index 1.

Accordingly, the present invention provides an effective and efficient method for
5 determining whether the pixel of the image sensor is defective during operation of the image sensor. The following color processing and image compression etc can be significantly simplified. In addition, the method of defective pixel address detection for image sensor is in a simple and low cost way.

It will be apparent to those skilled in the art that various modifications and
10 variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

WHAT IS CLAIMED IS:

1. A method of defective pixel address detection for an image sensor, comprising:

(a) comparing a defective pixel address with a sensor address, wherein the defective pixel address is stored in a memory element in advance when the image sensor is tested;

(b) outputting a defective pixel flag if the sensor address is equal to the defective pixel address;

(c) increasing an index value by one unit and returning to the step (a);

(d) comparing the defective pixel address with an empty signature if the sensor address is not equal to the defective pixel address;

(e) increasing the index value by one unit if the defective pixel address is equal to the empty signature, and returning to the step (a); and

(f) returning to the step (a) if the defective pixel address is not equal to the empty signature.

2. The method of claim 1, wherein the defective pixel address stored in the memory element is in an ascending order.

3. The method of claim 1, wherein the memory element is a fuse array.

4. The method of claim 1, wherein the defective pixel address stored in the memory element is in a format consisting of a row address and a column address of the image sensor.

5. A method of defective pixel address detection for an image sensor, comprising the steps of:

storing a plurality of defective pixel addresses during the image sensor is tested
reading a pixel address of the image sensor;

fetching one of the defective pixel addresses;

comparing the first fetched defective pixel address with the pixel address of the sensor address;

outputting a defective pixel flag if the pixel address is equal to the defective pixel address;

increasing an index value by one unit and fetching another defective pixel address which is indexed next to the first fetched defective pixel address;

comparing the defective pixel address with an empty signature if the pixel address is not equal to the defective pixel address;

increasing the index value by one unit if the defective pixel address is the empty signature, and then fetching another defective pixel address which is indexed next to the first fetched defective pixel address; and

fetching another defective pixel address which is indexed next to the first fetched defective pixel address if the defective pixel address is not the empty signature.

6. The method of claim 5, wherein the plurality of the defective pixel addresses are stored in a memory element.

7. The method of claim 6, wherein the defective pixel addresses stored in the memory element is in as ascending order.

8. The method of claim 6, wherein the defective pixel address stored in the memory element is in a format consisting of a row address and a column address of the image sensor.

9. The method of claim 6, wherein the memory element is a fuse array.

10. A device of defective pixel address detection for an image sensor, comprising:

a memory element, for storing a plurality of defective pixel addresses during the image sensor is tested; and

a address comparator, coupling to the memory element, for receiving a pixel address of the image sensor and one of the defective pixel addresses, and then comparing the pixel address of the image sensor and the defective pixel addresses, wherein the address comparator outputs a defective pixel flag if the pixel address is equal to the defective pixel address.

11. The device of claim 10, wherein the memory element is a fuse array.

12. The device of claim 10, wherein the memory element further comprises an index for indicating a location of one of the defective pixel addresses.

13. The device of claim 10, wherein the defective pixel addresses are arranged in an ascending order in the memory element.

ABSTRACT OF THE DISCLOSURE

A method of defective pixel address detection for image sensor. During the image sensor is tested, a number of defective pixel addresses of the image sensor are stored into a memory element and indexed. Each of the pixels of the image sensor is read in sequence and then compared with the indexed defective pixel address. If the sensor address is equal to the indexed defective pixel address, a defective pixel flag is outputted and then the index is increased by one. If the sensor address is not equal to the defective pixel address, the defective pixel address is compared with an empty signature. After the index is increased or the defective pixel address is not an empty signature, the detection process is continued.

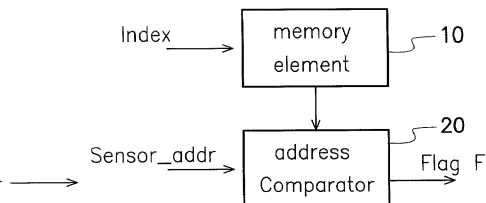


FIG. 1

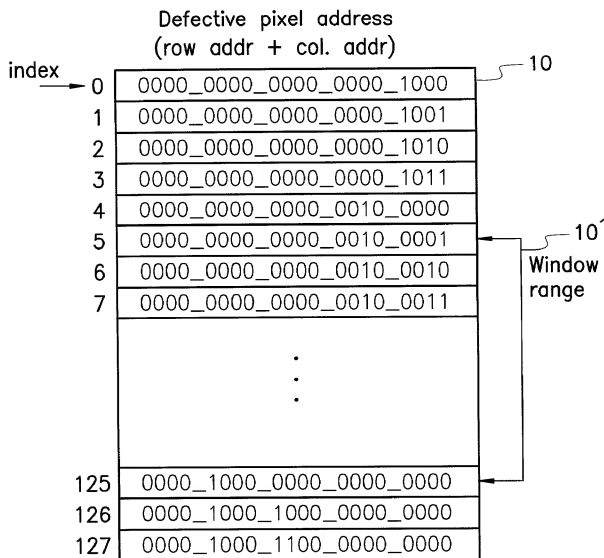


FIG. 2

| | |
|---|--------------------------|
| Defective pixel address (Row addr + Col. addr) | |
| index → 0 | 0000_0000_0000_0000_0100 |
| 1 | 0000_0000_0000_0000_0101 |
| 2 | 0000_0000_0000_0000_0110 |
| | ⋮ |
| 126 | 1111_1111_1111_1111_1111 |
| 127 | 1111_1111_1111_1111_1111 |

FIG. 3

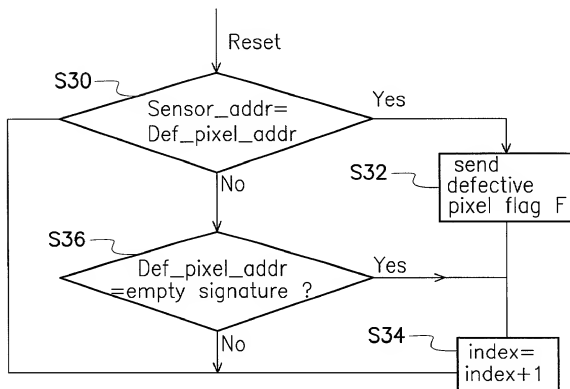


FIG. 4

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name and that I believe I am an original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD OF DEFFECTIVE PIXEL ADDRESS DETECTION FOR IMAGE SENSORS

the specification of which

X is attached hereto.

_____ was filed on _____

as Application Serial No. _____ and was amended on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below, and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, code of Federal Regulations, § 1.56, which became available between the filing date of the prior application and the national or PCT international filing date of this application:

PRIOR U.S.A. PROVISIONAL AND/OR NONPROVISIONAL APPLICATION(S)

Application No. : 60/217,824 **Filing Date:** July 12, 2000 **Status:** Pending

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

Signature:  Date 09/12/00

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